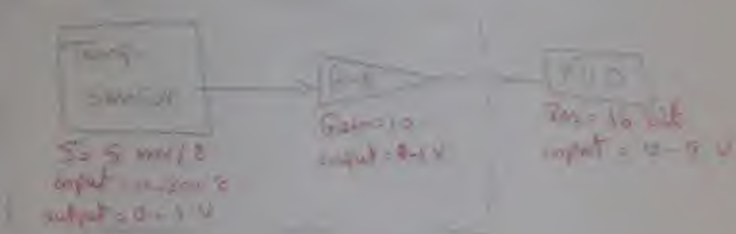
② Find The overall resolution in °C/bit

If The Amplifier is removed, find The A/D required to have The same resolution



Sol

A/D resolution:

$$= \frac{V_{max} - V_{min}}{Q} = \frac{V_{max} - V_{min}}{2^n} = \frac{5-0}{2^{16}} = 7.63 * 10^{-5} \ \frac{volt}{bit}$$

$$= (7.63 * 10^{-5}) * 10^3 \ mV = 0.076 \ \frac{mVolt}{bit}$$

$\therefore$ (Temp sensor & Amp) sensitivity:

$$S = 5 * 10 = 50 \ mV/°C$$

$\therefore$ The overall resolution $= \frac{A/D \ res}{S} = \frac{0.076}{50}$

$$= 1.52 * 10^{-3} \ \frac{°C}{bit}$$

If The Amp is removed

$S = 5 \ mV/°C$ & over all $Res = 1.52 * 10^{-3} \ \frac{°C}{bit}$

∴ over all $Res = \frac{A/D \ res}{S} = \frac{A/D \ res}{5} = 1.52 * 10^{-3} \ \frac{°C}{bit}$

∴ $A/D \ res = 1.52 * 10^{-3} * 5 = 7.6 * 10^{-3} \ \frac{mV}{bit}$

$$A/D \ res = \frac{\Delta V}{Q} = \frac{V_{max} - V_{min}}{2^n}$$

$$2^n = \frac{V_{max} - V_{min}}{A/D \ res} = \frac{(5-0) * 10^3 \ mV}{7.6 * 10^{-3} \ \frac{mV}{bit}} = 657894.7 \ bit$$

∴ $n \ln(2) = \ln(657894.7)$

∴ $n = 19.33 \ bit \approx 19 \ bit$

Q3 Find Range, span, ISL, N(I), H(I) [illegible]

[illegible]

[illegible]

Range: input Range = (0 - 10) Mpa
output Range = (4 - 20) mA

Span: input span = 10 - 0 = 10 Mpa
output span = 20 - 4 = 16 mA

ISL: $O_{ideal} = KI + a$

$K = \frac{\text{output span}}{\text{input span}} = \frac{16}{10} = 1.6 \ \frac{mA}{Mpa}$

$a = 4 \ mA$

$\therefore O_{ideal} = 1.6\, I + 4$

[illegible]

$N(I) = O_{act} - O_{ideal}$ $\Big\}$ $N(I)\% = \frac{N(I)}{\text{output span}} \times 100$

$H(I) = O_{act}\downarrow - O_{act}\uparrow = O_{act}\downarrow - O_{ideal}$

O_{ideal}	4	5.6	7.2	8.8	10.4	12	13.6	15.2	16.8	18.4	20
$N(I) = H(I)$	0	0.3	0.6	1.4	1.2	1.5	1	0.8	0.5	0.1	0
$N(I)\%$	0%	1.875%	3.75%	8.75%	7.5%	9.375%	6.25%	5%	3.125%	0.625%	0%

b)

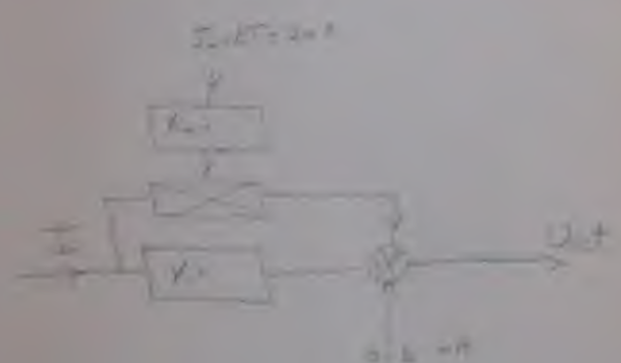
$$O_{act} = K' I + a' = (K + K_m I_m) I + (a + \Delta a)$$

$$= K I + K_m I_m I + a$$

$$\Delta K = K_m I_m = \frac{2}{100} * K * \Delta T$$

$$= \frac{2}{100} * 1.6 * (50 - 30) = 0.64 \quad \frac{mA}{MPa}$$

$$\therefore O_{act}\Big|_{I=5} = (1.6 + 0.64) * 5 + 4 = 15.2 \quad mA$$



$\bar{R}_1 = 1000\ \Omega$, $\bar{R}_2 = 500\ \Omega$, $U_{\bar{R}} = \pm 2\ \Omega$

Find $\bar{R}$, U_{R_1} , U_{R_2} $\rightarrow$ series & Parallel

sol

a) series :

$$\bar{R} = \bar{R}_1 + \bar{R}_2 = 1000 + 500 = 1500\ \Omega$$

$$U_{\bar{R}} = \pm\sqrt{\left(U_{R_1}\frac{\partial R}{\partial R_1}\right)^2 + \left(U_{R_2}\frac{\partial R}{\partial R_2}\right)^2} = \pm 2$$

$$\frac{\partial R}{\partial R_1} = \frac{\partial R}{\partial R_2} = 1$$

$$\therefore \pm 2 = \pm\sqrt{(U_{R_1})^2 + (U_{R_2})^2}$$ بتربيع الطرفين

$$4 = (U_{R_1})^2 + (U_{R_2})^2$$

assuming that $U_{R_1} = U_{R_2}$

$$\therefore 4 = 2(U_{R_1})^2$$

$$(U_{R_1})^2 = \frac{4}{2} = 2$$

$$\therefore U_{R_1} = U_{R_2} = \pm\sqrt{2}\ \Omega$$

b) Parallel :

$$\bar{R} = \frac{R_1 R_2}{R_1 + R_2} = \frac{1000 \times 500}{1500} = 333\ \Omega$$

$$U_{\bar{R}} = \pm\sqrt{\left(U_{R_1}\frac{\partial R}{\partial R_1}\right)^2 + \left(U_{R_2}\frac{\partial R}{\partial R_2}\right)^2} = \pm 2$$

$$\frac{\partial R}{\partial R_1} = \frac{R_2(R_1+R_2) - R_1 R_2(1)}{(R_1+R_2)^2} = \frac{1}{9}$$

$$\frac{\partial R}{\partial R_2} = \frac{R_1(R_1+R_2) - R_1 R_2(1)}{(R_1+R_2)^2} = \frac{4}{9}$$

$$\therefore \pm 2 = \pm\sqrt{\left(\frac{U_{R_1}}{9}\right)^2 + \left(\frac{4U_{R_2}}{9}\right)^2}$$

بتربيع الطرفين

$$4 = \frac{U_{R_1}^2}{81} + \frac{16\,U_{R_2}^2}{81}$$

assuming that $U_{R_1} = U_{R_2}$

$$4 = \frac{U_{R_1}^2}{81} + \frac{16\,U_{R_1}^2}{81} = \frac{17\,U_{R_1}^2}{81}$$

$$\therefore U_{R_1}^2 = \frac{4 \times 81}{17} = 19.1$$

$$\therefore U_{R_1} = U_{R_2} = 4.84\ \Omega$$

Force (KN)	0	10	20	30	40	50	60	70	80	90	100
Voltage ↓ E (mV)	15	21	26.5	33	40	46	48	51	55.3	60.1	65
Voltage ↑ E (mV)	15	18	22	26.5	32	37	42	48	56	59.5	65

Find: Range, span, I.S.L, [N(I)], [H(I)] as percentage of [FSO]
The instrument is calibrated at (30 [illegible]) ... ΔK_I = [illegible]
* [illegible] calculate the [illegible] [illegible] mV for input 50 KN

sol?

* Range: Input = (0 - 100) KN, output Range (15 - 65) mV

* span: input span = $F_{max} - F_{min} = 100 - 0 = 100$ KN.
output span = $E_{max} - E_{min} = 65 - 15 = 50$ mV.

* I.S.L: $O_{ideal} = E_{ideal} = KF + a$

$K = \frac{\text{output span}}{\text{input span}} = \frac{50}{100} = 0.5$ mV/KN.

$a = 15$ mV $\Rightarrow \therefore E_{ideal} = 0.5F + 15$

$N(I) = N(F) = E_{act} - E_{ideal}$

$H(I) = H(F) = E\downarrow - E\uparrow$

I ↓	15	20	25	30	35	40	45	50	55	60	65
H(F)↓	0	1	1.5	3	5	4	3	1	0.3	0.1	0
H(F)↑	0	-2	-5	-3.5	-3	-3	-3	-2	-1	-0.5	0
H(F)	0	3	6.5	6.5	8	7	6	3	1.3	0.6	0

$$H(F)\% = \frac{H(F)}{\text{out span}} * 100 = \frac{8}{50} * 100 = 16\ \%$$

$$E_{out} = K' I + a' = K\cancel{F + K_m F_m} + KF + K_m I_m F + a + K_I I_c$$

$$= KF + K_m I_m F + a + \Delta a$$

$$\Delta a = 2\ \%/c\ \text{FSO} = \frac{2}{100} * [\text{output span}] * \Delta T$$

$$= \frac{2}{100} * [50] * [50 - 30] = 20\ \text{mV}$$

$$E)_{50\,kN} = 0.5 * 50 + 15 + 20 = 60\ \text{mV}$$